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# Solar powered micro-irrigation system for small holders of dryland agriculture in India

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ABSTRACT

Small water harvesting ponds are crucial to sustain productivity by providing supplemental/life saving irrigation in the small holdings of Indian dryland agriculture. Applications of such water however, are always a major issue in these regions, since efficient and cost effective pumping system is generally not available. In order to achieve the holistic utilization of water resources, a gravity-fed type micro-irrigation system integrated with low cost solar based pumping system was designed. The system was designed considering the properties of flow characteristics derived from hydraulic study of different components of drip irrigation system. The system thus developed, has the capability to provide uniform emitter discharge over the small plot of 18 m × 6 m. The star configuration of micro-tube layout where the lateral line feed four rows as devised by Bhatnagar and Srivastva (2003), was successfully integrated in the developed irrigation system. The field experimentation and testing suggested that the system performance was found satisfactory as the flow rate variation, Christiansen uniformity coefficient and distribution uniformity were 18.96%, 93.65% and 91.55% respectively.



## 1. Introduction

Dryland agriculture is most prominent in arid, semi-arid and sub-humid regions of Indian subcontinents. These regions are home to about 81% rural poor in the country. 55% of Indian agriculture pertains to dryland agriculture where majority of farmers are practicing subsistence farming due to over dependency on rain. The major ecological and economical factors that make agriculture unsustainable in this region, includes rainfed cultivation, small and fractured land holdings, insufficient crop yield and limited scope to adopt intensive agriculture. Many government funded watershed development program in this region are currently practiced and are mostly emphasized to increase the water availability in the vicinity through various activities involving surface water harvesting and utilization. The water harvesting mostly achieved in small ponds (capacity < 1000 $m^3$ and depth less than 4 m) and recycled as life saving irrigation/supplemental irrigation to attain sufficient soil moisture for successful crop production (Anbumozhi et al., 2001).

The major impediments in realizing the potential of water harvesting and recycling in dryland agriculture of India however, is the economical and effective means to lift water and distribute the same in the field. Namara et al. (2007), in their studies in Maharashtra and Gujarat state of India found significantly positive effect of ownership of well and high horsepower pumps on likelihood of adaptation of micro-irrigation technologies. This directly or indirectly suggests that the cost of energy in irrigation is the major factor. Several energy efficient interventions in micro irrigation have been reported in the literature such as bucket kits (Fandika et al., 2012), IDE low-cost drip irrigation (Polak et al., 1997a,b; Van Westarp et al., 2004), Drum kit (Karlberg et al., 2007; Kulecho and Weatherhead, 2005), gravity-fed micro irrigation (Bhatnagar and Srivastva, 2003; Kumar et al., 2009) and Pepsee system (Verma et al., 2004).

The existing pumping system adopted in the region depends upon the supply of either electricity or fossil fuels. Additionally, the existing lifting pumps for drawing water from bore-well have high suction:delivery head ratio, are uneconomical for small-scale applications. Affordability of these systems to the smallholding farmers is a major concern as the operational cost overshadowed the profitability. Thus to avoid these economic liabilities associated with existing pumping system and increase the profitability from limited land and climate resources, this class of farmers usually goes for hand watering. Thus, in these conditions, the most befitting pumping system should have low suction:delivery ratio.

Micro-irrigation technologies are widely considered as one of the most effective and efficient method of irrigation (Keller and Bliesner, 1990). Several studies in the past have been carried out

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to demonstrate higher water use efficiency and water productivity. Some of those from studies from Indian subcontinent suggested as typical yield increases of 20–50% for a variety of crops namely, cotton, sugarcane, grapes, tomatoes, banana etc. (Indian National Committee on Irrigation and Drainage, 1994; Sivanappan, 1994). In practice, these techniques are often associated with capital intensiveness and thus suitable for commercial farming on large field for big farm holders and at large, unaffordable for smallholders since these systems are not available in sizes matching small plots. However, these technologies have undergone through technical and innovational interventions to make low cost micro-irrigation system (Polak et al., 1997a,b; Verma et al., 2004; Upadhyay, 2003) viable.

The micro-irrigation in Indian dryland agriculture are promoted with the single or combined objective as listed by Namara et al. (2007), (i) to save the irrigated agriculture from crises of water scarcity, (ii) to increase water productivity to achieve increase in household income and eventually poverty reduction and (iii) to address the issue of food and nutritional security. Namara et al. (2007) using random sampled data of 448 farmers in Maharashtra and Gujarat state of India, concluded that the drip irrigation was adopted by those farmers who has access to ground water and own higher capacity of pumps (6.6 hp against 3.8 hp and 4.01 hp against 0.6 hp in case of adopters against non-adopters for Maharashtra and Gujarat respectively). The carry-and-irrigate scheme, introduced in Andhra Pradesh state of India in 2005 under state funded micro-irrigation project (APMIP scheme) where the farmers are supplied with five sprinkler heads, which is sufficient to cover 0.4 ha land to enhance water use efficiency. These systems however, grossly used ground water as a source that caused depletion of ground water in the region.

The present work describes the work attempted to develop solar powered micro-irrigation system with the strategies to address the limitations of drip irrigation for smallholders. These includes, (1) development of micro-irrigation system that operates with low pressure, (2) matching pumping scheme to draw water from small-scale water harvesting ponds and (3) introducing an economical and efficient alternative micro-irrigation system by attaining the perfect match between water available and area under command for extensive small-scale vegetable production. Due consideration of the techno-socio-economic situation of the small and marginal farmers of the regions were considered while developing this system.

## 2. Material and methods

### 2.1. Location of study

The research was conducted at the research farm (located at 17°37′N and 78°48′E) of Central Research Institute for Dryland Agriculture, Hyderabad located at south-central India. Location typically represents the dryland farming situation of semi arid region with Alfisols and vertisols being the major soil prevailing in the region. The region receives average annual rainfall of 750 mm in which 80% rainfall is received during monsoon months (15$^{th}$June to 15$^{th}$ October) allowing to practice one crop. However, second and third crops are also practiced in some pockets of the area where intensive irrigation facility (mostly ground water) exists.

### 2.2. Development of micro-irrigation system

The proposed micro-irrigation system essentially employs principles of hydraulic characteristics of pressurized pipe flow. The micro-irrigation system is the assembly of several components that convert the continuous flow of water into drop flow to achieve higher water use efficiency. Conventionally, micro-irrigation system directly connected to delivery head of the pump requiring high pressure at the delivery head for proper functioning. For these systems, usually the source of water being the ground water and therefore a pump of capacity of 5 hp or more running on either electricity or fossil fuels is essential for successful operation. Thus the conventional irrigation system prohibits the use of surface water and demands the compulsory choice of higher capacity pump causes gross mismatch between size of pump and available plot size. The solar version for this configuration further requires huge investment making this a costly preposition. In view of these facts, the present innovation was derived addressing the three major issues to substantiate the sustenance farming of dryland agriculture practiced by small and marginal farmer.

1. Utilization of surface water from small scale water harvesting.
2. Minimizing the dependency on energy either from electricity, fossil fuels or both and so enabling in reducing the carbon footprint.

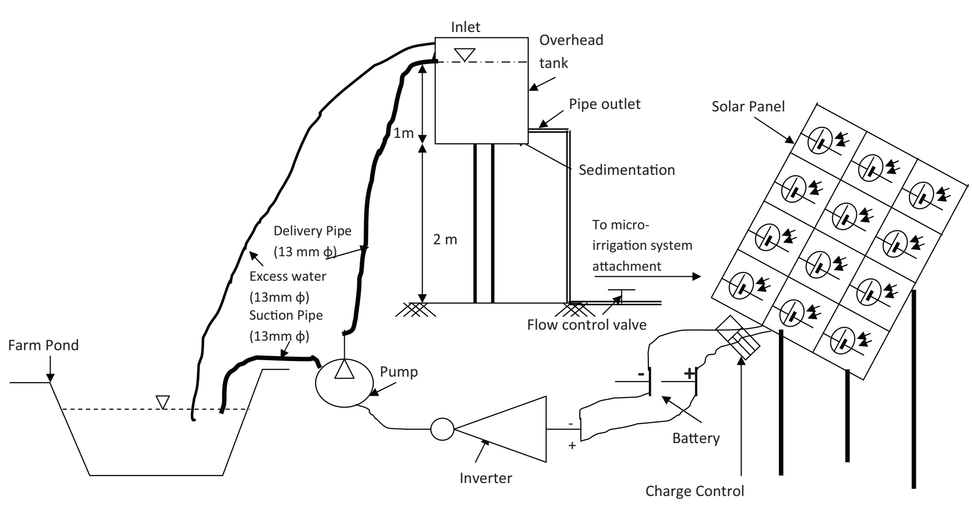


**Fig. 1.** Schematic diagram of solar powered micro-irrigation system.